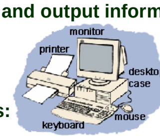
Computer Architecture

JIANGJIANG LIU

Department of Computer Science
Lamar University

Computer Components

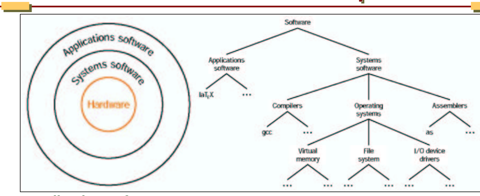
- A device to receive, process, and output information



- Has two types of components:
  - Software components:
    - Facilitate the use of computer
    - Studied and designed by computer scientists
  - Hardware components:
    - The hardware that receives, processes, and outputs information
    - Studied and designed by computer engineers
- Need knowledge of both software and hardware components to design competitive computers

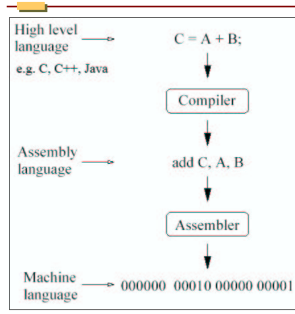
---

Software and Hardware Components



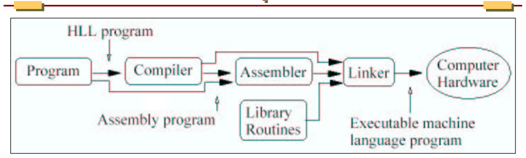
- Application software
  - Programs aimed at computer users
    - Windows: Microsoft Word, Photoshop, Realplayer, Taxcut, etc.
    - Unix: Latex, xfig, xemacs, etc.
- System software
  - Software that provides services that are commonly useful
    - Operating systems, compilers, and assemblers
- Hardware

Software Languages



- Advantages of high level language (HLL)
  - Closer to natural language
  - Use English word and algebraic notation
  - Benefits
    - Easier to use
    - Improve programmer productivity
    - Portability: independent of computer
- Assembly language still used in small, time-critical applications
  - e.g., embedded computers in cars
- Machine language
  - Numbers in base 2, or binary numbers

Levels of Representation



- HLL
- Assembly
- Machine language

```
swap:
    temp = v[k];
    v[k] = v[k+1];
    v[k+1] = temp;
```

```
swap:
    lw   $15, 0($2)
    lw   $16, 4($2)
    sw   $16, 0($2)
    sw   $15, 4($2)
```

```
swap:
0000 1001 1100 0110 1010 1111 0101 1000
1010 1111 0101 1000 0000 1001 1100 0110
1100 0110 1010 1111 0101 1000 0000 1001
0101 1000 0000 1001 1100 0110 1010 1111
```

Machine Language

- Translate a assembly instruction into a machine instruction
  - Assembly instruction
    - Add $t0, $s1, $s2 ($t0=$s1+$s2)
  - Machine instruction

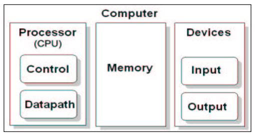
0	17	18	8	0	32	Decimal representation
6 bits	5 bits	5 bits	5 bits	5 bits	6 bits	
000000	10001	10010	01000	00000	100000	Binary representation
6 bits	5 bits	5 bits	5 bits	5 bits	6 bits	

- Instruction fields

op	rs	rt	rd	shamt	funct
6 bits	5 bits	5 bits	5 bits	5 bits	6 bits

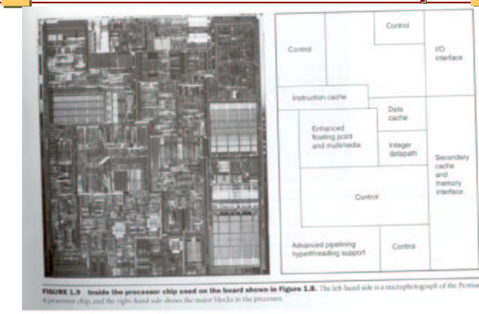
- op: Basic operation of the instruction, called opcode
- rs: The first register source operand (e.g., $s1)
- rt: The second register source operand (e.g., $s2)
- rd: The register destination operand (e.g., $t0)
- Shamt: Shift amount
- Funct: Function

Computer System



- Computation system: Processor (central processor unit)
  - Add numbers, test numbers, signal I/O devices to active
    - Control: determine operations of datapath, memory, I/O devices
    - Datapath: perform arithmetic operations
- Memory system:
  - Main memory
  - Secondary memory
- I/O system: Secondary and tertiary storage I/O, network I/O

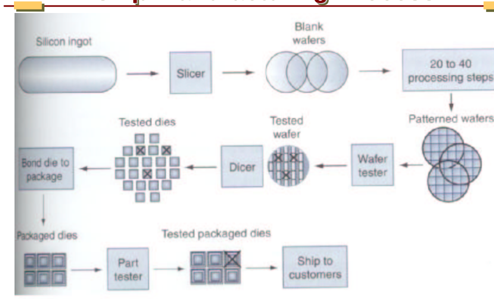
Pentium 4 Processor Chip



Technologies for Building Processors

Year	Technology	Relative performance /unit cost
1951	Vacuum tube	1
1965	Transistor	35
1975	Integrated circuit	900
1995	Very large scale integrated circuit	2,400,000
2005	Ultra large scale integrated circuit	6,200,000,000

Chip Manufacturing Process



Cost

- Cost per die
  - Cost per die = $\frac{\text{Cost per wafer}}{\text{Dies per wafer * Yield}}$
- Dies per wafer
  - Dies per wafer = $\frac{\text{Wafer area}}{\text{Die area}}$
- Yield
  - Percentage of good dies that fit on a wafer
  - Defects: microscopic flaw in wafer
  - Yield = $\frac{1}{(1+(\text{Defects per area * Die area}/2))^2}$
  - Based on years of empirical observations of yields at integrated circuit factories, with the exponent related to the number of critical processing steps in the manufacturing process.